Little Corella *(Cacatua sanguinea)*. Very common, in large numbers along the river.
Galah *(Cacatua roseicapilla)*. Common around townsite and river.
Cockatiel *(Leptolophus hollandicus)*. Four birds observed flying over the rubbish dump on one occasion.
Port Lincoln Parrot *(Barnardius zonarius)*. Common along river.
Blue-winged Kookaburra *(Dacelo leachii)*. Common along river.
Sacred Kingfisher *(Halcyon sancta)*. Common along river.
Rainbow-bird *(Merops ornatus)*. Noted as common along river.
White-backed Swallow *(Cheramoeca leucosterna)*. Observed on two occasions along the river.
Welcome Swallow *(Hirundo neoxena)*. Observed on one occasion near the river crossing.
Fairy Martin *(Petrochelidon ariel)*. Common along the river.
Pipit *(Anthus novaeseelandiae)*. Very common around townsite.
Black-faced Cuckoo-Shrike *(Coracina novaehollandiae)* found in small numbers around town, river, and creeks.
Crested Bell-bird *(Oreoica gutturalis)*. Observed on one occasion singing from a small bush, near the junction dam.
Willy Wagtail *(Rhipidura leucophrys)*. Common in small numbers.
Wedgebill *(Psophodes occidentalis)*. Moderately common in the open scrub country.
Cinamon Quail-thrush *(Cinclosoma cinnamomeum)*. One bird sighted on road leading to junction dam.
White-browed babbler *(Pomatostomus superciliosus)*. Moderately common in small numbers in country bordering the river.
White-winged Wren *(Malurus leuconotus)*. Common in the open scrub country.
Banded White-face *(Aphelocephala nigricincta)*. Observed eight birds on rocky country, south of the townsite.
Spiny-cheeked Honeyeater *(Acanthagenys rufogularis)*. Common on the river, and around the junction dam. Always near water.
Yellow-throated Miner *(Manorina flavigula)*. Very plentiful along the river.
Singing Honeyeater *(Meliphaga virescens)*. Observed in small numbers around the junction dam.
White-plumed Honeyeater *(Meliphaga penicillata)*. Very common along the river and in the townsite. The most common of the honeyeaters.
Zebra Finch *(Taeniopygia castanotis)*. Common near the river, and the open country.
Mudlark *(Grallina cyanoleuca)*. Common along the river and townsite.
Black-faced Woodswallow *(Artamus cinerens)*. Observed in small numbers in the open scrub country.
Pied Butcher-bird *(Cracticus nigrogularis)*. Very common in townsite and in small numbers on the river. Both adult and immature birds sighted.
Black-backed Magpie *(Gymnorhina tibicen)*. Common around the town, and on the river.
Crow? *(Corvidae)*. I was unable to identify this species without a hand held specimen. However it was only sighted in very small numbers in the areas visited. Largest flock sighted was of four birds.

SEASONAL VARIATIONS IN THE ABUNDANCE AND FOOD PREFERENCES OF HONEYEATERS *(MELIPHAGIDAE)* AT WONGAMINE, WESTERN AUSTRALIA

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ABSTRACT

Populations of honeyeaters were studied at Wongamine, W.A. for a period of two years from December, 1976. Seasonal changes in food preferences and abundance of the major species were recorded and related to the flowering phenology and nectar (energy) production by plants in the study areas. Although all honeyeaters seemed to be opportunistic feeders, they did show preferences for certain plants that seemed to be based largely on the total energy made available by these plants.

INTRODUCTION

One of the most abundant and diverse families of Australian birds are the honeyeaters (Meliphagidae). Numerous recent studies have indicated that nectar is commonly used as a source of food by members of this group (e.g. Recher and Abbott, 1970; Ford and Paton, 1977; Paton and Ford, 1977; Collins and Clow, 1978; Collins and Morellini, 1979). Evidence has also been assembled which suggests that many of these birds make some use of other food resources such as insects and pollen (e.g. Ford and Paton, 1977; Pyke, 1979). One of the major purposes of this paper is to deseribe the food preferenees of several species of south-west Australian honeyeaters.

Seasonal variations in the population sizes of different honeyeaters in different parts of Australia have been reported. For instance, population shifts have been shown to occur as birds follow the flowering of plants (e.g. Keast, 1968). Even relatively sedentary populations show fluctuations in density and micro-habitat preference, presumably in response to changes in the availability of food and other environmental parameters (e.g. Slater, 1974; Collins and Clow, 1978). The second major objective of the present paper is to document variations in population densities of several south-west Australian honeyeater species, and attempt to explain these changes in terms of the flowering phenology of plants visited by the birds.

MATERIALS AND METHODS

Investigations were carried out at the Wongamine Fauna and Flora Reserve, 125 kilometres north-east of Perth, Western Australia. This reserve is 259 hectares in area and is surrounded by agricultural land. The study area selected within the reserve comprised approximately five hectares of heath, surrounded by *Eucalyptus-Dryandra* woodland.

Several honeyeater species were found to occur in the study area. All of these were seen to probe the flowers of plants at some stage. Species such as the Yellow-plumed Honeyeater *(Meliphaga ornata)*, Tawny-crowned Honeyeater *(Gliciphila melanops)* and the Red Wattlebird *(Anthochaera carunculata)* appeared to be present in very small numbers, and have therefore been excluded from further consideration in this paper. The four species for which data were gathered are the Western Spinebill *(Acanthorhynchus superciliosus)*, the Brown Honeyeater *(Lichmera indistincta)*, the Brown-headed Honeyeater *(Melithreptus brevirostris)* and the White-cheeked Honeyeater *(Phylidonyris nigra)*.

Over a period of two years, commencing in December 1976, observations of birds present in the study area were made at intervals of approximately three months. Records were kept of the numbers and species of birds observed, the plants visited and the feeding strategies adopted.

Mist nets were used to capture birds at the sampling sites. After measurement of body weight, each bird was placed in a small wire trap under which paper tissues were spread. Faecal samples deposited on the tissues were subsequently stained with methylene blue and examined under the microscope for evidence of pollen grains and pieces of arthropod exoskeleton.

All plants visited by honeyeaters were identified, and their habits and floral characteristics recorded. Representative members of each species were marked with numbered tags so that estimates of flower abundance could be made on the same plants during each visit to the study area. Pollen was collected from representative plants and used as a basis for identification of pollen grains present in faecal samples obtained from honeyeaters. Capillary tubes were also used to measure the early-morning "standing crops" of nectar present in representative flowers from each species.

RESULTS

Numerous plant species were found in the study area. Although most of these were used as refuges by honeyeaters on occasions, only those listed in Table 1 had flowers that were probed by the birds. In some cases, the

flowers were separate. In others, they were grouped in multiple heads such as those found in *Banksia* and *Dryandra*. There were also considerable variations in flower colour, appearance of pollen grains, "standing crop" volumes of nectar, and accessibility of the nectar to honeyeaters. The only species from which nectar could not be collected was *Nuytsia floribunda*. Nevertheless, it was observed that the flowers of this species produced copious quantities of pollen, attracted large numbers of insects and were frequently probed by several honeyeater species.

TABLE 1.—CHARACTERISTICS OF PLANT SPECIES VISITED BY HONEYEATERS AT WONGAMINE RESERVE.

Plant species	Habit	Abundance	Flowering† season	Mean nectar* volume (μl/flower)	Pollen grain shape
Adenanthos argyrea	small shrub	rare	Aug-Dec(Sep)	11.3	triangular
Adenanthos cygnorum	medium shrub	common	May-Nov(Jun-Sep)	13.0	triangular
Anigozanthus humilis	small shrub	rare	Aug-Oct(Sep)	15.0	cylindrical
Banksia attenuata	small tree	rare	Sep-Jan(Dec)	200.0	kidney-shaped
Calothamnus quadrifidus	large shrub	abundant	Nov-Jan(Dec)	9.6	triangular
Calothamnus sanguineus	medium shrub	common	Apr-Oct(Jun)	8.5	triangular
Dryandra sessilis	small tree	ebundent	May-Nov(Sep)	54.3	banana-shaped
Eucalyptus drummondii	medium tree	common	May-Oct(Sep)	39.4	triangular
Eucalyptus macrocarpa	straggling mallee	rare	Oct-Jan(Dec)	164.0	triangular
Eucalyptus wandoo	large tree	common	Apr-Sep(Jun)	—	triangular
Nuytsia floribunda	medium	rare	Nov-Jan(Dec)	—	triengular

†Name of month abbreviated using first three letters; month of peak flower abundance shown in brackets.

*Nectar samples were "standing crops" collected at various times between 0600 and 0900 hrs; "flower" should be taken to designate a single flower or multiple head, depending on the plant species concerned.

The flowering seasons of plants visited by honeyeaters are indicated in Table 1. At least one species is in flower, and thus nectar is available, for most times of the year, apart from late January, February and perhaps early March.

TABLE 2.—ABUNDANCE AND FEEDING HABITS OF HONEYEATERS STUDIED

Species	Body weight (gm)	Overall abundance	Time of* peak density	Time of minimum density/ absence*	Evidence of food eaten Nectar	Arthropods	Pollen
Acanthorhynchus superciliosus	10.8 ± 0.7	rare	Sep	Jan-Mar	•	•	•
Lichmera indistincta	11.1 ± 0.8	abundant	Sep-Dec	Jan-Mar	•	•	•
Melithreptus brevirostris	12.8 ± 0.7	common	Jun	Nov-Apr	•	•	•
Phylidonyris nigra	18.3 ± 1.1	common	Sep-Dec	Jan-Apr	•	•	•

*Name of month abbreviated as in Table 1.

Lichmera indistincta is the dominant honeyeater species at Wongamine, both numerically and in terms of persistence in the area throughout the year (Table 2). Nevertheless, there does not seem to be a clear par-

titioning of floral resources between this and other honeyeater species for most of the year. Instead, the birds that are present tend to visit most plants that are in flower. This observation is supported by the existence of a variety of pollen grain types in all bird faeces. It was noted, however, that the flowers of some plants were more frequently probed than those of others, e.g. *Dryandra sessilis* and *Eucalyptus drummondii* were both more "popular" with *Lichmera indistincta* than *Calothamnus sanguineus* and *Adenanthos cygnorum* in September. Some evidence was also obtained which suggested that daily temporal changes in flower preference sometimes occurred. For instance, it appeared that *Lichmera indistincta* at Wongamine in September, 1978, favoured the flowers of *Eucalyptus drummondii* early in the morning, whereas *Dryandra sessilis* was visited more frequently later in the day.

Within the study area, honeyeaters tended to be most abundant where plants were in flower. For instance, during the period from June to September, they occurred mostly in the *Eucalyptus-Dryandra* woodland. By December, however, very few honeyeaters were to be sighted in this area; instead, they were abundant in and around the *Calothamnus quadrifidus* heath association.

In addition to probing flowers, most honeyeater species were seen to capture arthropods by hawking and/or gleaning from the bark of plants, and all produced faeces containing arthropod exoskeletons. The general impression obtained, however, was that overt arthropod capture was much less frequent than flower probing.

DISCUSSION

Evidence presented in this paper suggests that many, if not all, of the honeyeaters present at Wongamine feed by probing a variety of flowers and either hawking or gleaning for arthropods. These observations are generally in accord with those reported for a variety of honeyeaters at other locations (e.g. Recher and Abbott, 1970; Ford and Paton, 1976; Ford and Paton, 1977). There is no doubt that pollen is ingested by honeyeaters when they probe flowers. In many instances, faecal samples were packed with pollen grains, some of which appeared to be empty. Nevertheless, the precise nutritional role of pollen remains uncertain. Churchill and Christensen (1970) have argued that pollen from Karri *(Eucalyptus diversicolor)* is a major energy-releasing component of the staple diet for the brush-tongued Purple-crowned Lorikeet *(Glossopsitta porphyrocephala)* in south-western W.A., but Hopper and Burbidge (1979) have recently raised serious doubts as to whether this is correct. It now seems more likely that pollen supplements arthropods and nectar as a source of amino-acids. If this is the situation in honeyeaters, most of the energy required would presumably be supplied either by carbohydrates that are present in the nectar or by arthropods (Collins and Clow, 1978; Collins and Morellini, 1979). More information must be gathered before the relative value of arthropods and nectar as energy sources can be accurately assessed, although the close agreement between flower density and apparent honeyeater abundance suggests that nectar may be generally more important.

Assuming that nectar is usually the principal energy source, there would seem to be few occasions when individual birds might be expected to prefer nectar from a particular plant species at Wongamine because of its superior calorific (energetic) value. For instance, *Eucalyptus drummondii, Adenanthos cygnorum, Calothamnus sanguineus,* and *Dryandra sessilis,* which flower simultaneously for several months of the year, produce nectar with similar concentrations and energetic values (Collins and Morellini, 1979). *Eucalyptus macrocarpa* and *Banksia attenuata,* on the other hand, produce significantly less concentrated nectar in December at Wongamine than does *Calothamnus quadrifidus,* and might therefore be less attractive to honeyeaters. The foraging strategy of the birds is unlikely, however, to be determined simply by the concentration of nectar available. Other factors such as the quantities of nectar produced and the

distances that birds have to fly in order to obtain the nectar would also be important.

"Standing crop" volumes of nectar obtained from the flowers of some plant species suggest that there are two classes of plant—those whose flowers contain relatively small volumes of nectar and those that are capable of producing large volumes. It would appear that the large volume producers are capable of making significantly greater quantities of energy available per flower than the plants that produce relatively little nectar (Table 3). When estimates of total energy availability are made, however, it becomes apparent that the major nectar (energy) producers on a flower-to-flower basis, are not necessarily those that make the greatest total contribution. A good illustration of this is given by plants located in the heath area at Wongamine in December. Although inferior in terms of energy produced per flower, *Calothamnus quadrifidus* has such a high flower density that it contributes far more total energy than either *Banksia attenuata* or *Eucalyptus macrocarpa*. This, together with the fact that energetic costs involved in moving from flower to flower in the dense stands of *Calothamnus quadrifidus* must be lower than for the other, more widely dispersed plants, helps to explain the popularity of this species with honeyeaters such as *Lichmera indistincta* and *Phylidonyris nigra*. Similar arguments can be advanced to explain the apparent preference for *Eucalyptus drummondii* and *Dryandra sessilis* during June and September.

TABLE 3.—ENERGY AVAILABILITY IN STUDY AREA AT WONGAMINE.

Plant species	Energy availability per flower (cal/flower)*	Peak flower numbers (fl/100m²)**	Total energy availability (cal/100m²)
(a) Small volume producers			
Adenanthos cygnorum	13.3	628(J)	8,352
Calothamnus quadrifidus	9.6	22,200(D)	213,120
Calothamnus sanguineus	7.7	528(J)	4,066
(b) Large volume producers			
Banksia attenuata	122.3	4(D)	489
Dryandra sessilis	79.6	267(J)	21,253
Eucalyptus drummondii	29.4	6,480(J)	190,512
Eucalyptus macrocarpa	77.7	8(D)	622

* Values calculated from data supplied in Table 1, assuming 1.3496 cal/μl for 34.2% sucrose solution (Collins and Morellini, 1979).

**(J) denotes values for June, and (D) December.

In addition to movements of honeyeaters associated with the flowering of plants, there are seasonal changes in overall honeyeater abundance; greatest bird densities generally correspond to periods of peak flower (energy) abundance. Nevertheless, there are significant differences between the patterns for different honeyeaters. For instance, *Lichmera indistincta* and *Phylidonyris nigra* are abundant in December, although *Melithreptus brevirostris* and *Acanthorhynchus superciliosus* have virtually disappeared from the study area by this time. Further investigations must be performed before it will be possible to explain such differences in bird abundance.

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NOTES ON THE BIOLOGY, DISTRIBUTION AND CONSERVATION OF *DRYANDRA ARBOREA* (PROTEACEAE)

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INTRODUCTION

Dryandra arborea C. A. Gardn. is the most recently described species of the endemic South-Western Australian genus, *Dryandra*. It is also the most inland member of this genus.

DISTRIBUTION

The species is confined to jasperlite (banded iron formations) hills in the North-Western Goldfields. Previously thought confined to the Die Hardy Ranges, Mt. Jackson and Koolyanobbing Ranges, surveys by the author with the Western Australian Museum Survey Department have located populations on the eastern ranges; Mt. Dimer, the Hunt Ranges and Bungalbin Ranges. We failed to locate any *Dryandra arborea* in the High Clere Hills (near Bullfinch) and the Mt. Manning Ranges were not visited.

The largest populations are found in the Mt. Jackson-Bungalbin Ranges which are contiguous by low jasperlite rises.

BIOLOGY

Dryandra arborea grows as a large shrub-small tree of up to 6 metres